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RESEARCH ARTICLE

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An evaluation of Headsprout early reading as an online parent-mediated intervention for primary school children

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Abstract

Due to the Coronavirus pandemic and lengthy absences from the classroom, there is a need for large-scale remedial programs to support young children to "catch-up" on literacy and numeracy skills. A stratified randomized controlled trial was used to evaluate the Headsprout Early Reading (HER) program as a parent-mediated digital literacy intervention. A between-groups design compared differences in reading-dependent outcome measures for 36 children assigned to one of three intervention groups: *with support*, *without support*, and *waitlist-control*. Children completed significantly more episodes when parents received implementation support from the researcher compared to the *without support* group. Children receiving Headsprout instructions demonstrated marginally greater gains than the waitlist-control group in posttest outcome measures; however, differences in reading outcomes were not significant between groups at posttesting. The current research provides tentative support for HER and importantly, highlights the importance of providing support for parents implementing interventions at home.

KEYWORDS
computer-assisted instruction, Headsprout, literacy, parent-mediated intervention, reading skills

1 | INTRODUCTION

As a result of the COVID-19 pandemic, disruptions to the education system have severely impacted children's learning with substantial losses in cognitive domains, such as literacy and numeracy skills. In Spring 2020, many schools across the world were forced to close, resulting in an unprecedented move toward online teaching for around 1.6 billion learners (World Bank, 2020). Kaffenberger (2021) proposed that a 3-month school closure could result in an accumulated learning loss equivalent to more than one full school year for some children. These findings are congruent with the learning losses identified by Andrabi et al. (2020) in the 4 years following short-term school closures in Pakistan as a result of the 2005 earthquake.

The World Bank Group (2020) predicts that foundational learning in early primary school will be particularly impacted by school closures. Young children are more reliant on parents to assist them with accessing remote-learning programs, leading to a decline in engagement as parents prioritize online education for older children. Disruption during this period of initial instruction for foundational learning skills may result in lower learning trajectories for a whole generation. This will be further exacerbated for disadvantaged children due to differential access to computer equipment, home conditions conducive to learning, and parental knowledge of academic subjects. Kaffenberger (2021) speculates that a failure to adapt the curriculum and instruction to children's lower learning levels upon their return to school could result in them falling further behind. The World Bank Group (2021) recently partnered with UNESCO and UNICEF to issue a mission statement in response to the pandemic, titled "Recovering Education in 2021.". It calls for the implementation of large-scale remedial programs to help children catch up on lost education and advocates for the use of digital technology to teach foundational literacy and numeracy skills.

1.1 | Computer-assisted instruction (CAI)

Computer-assisted instruction (CAI) refers to the instruction or remediation presented on a computer and is just one of the many techniques used by schools to supplement the instructional teaching of foundational reading skills (Rayner et al., 2001). Over the past decade, there has been much interest in the development of computer games that function as educational tools, particularly those merging empirically validated teaching methods based on applied behavior analysis with the motivational properties of computer games (Linehan et al., 2011; Morford et al., 2014).

Rogowsky et al. (2018) examined the effects of CAI on literacy and numeracy skills for preschoolers. Results of post-achievement tests revealed significant differences between groups, supporting the use of playful learning through educational software. These findings are consistent with other research supporting the use of CAI (e.g., Hall et al., 2000; Macaruso & Rodman, 2011; Messer & Nash, 2017; Verhoeven et al., 2020). CAI is engaging and allows students to work independently. It can also be tailored to meet specific learning needs and provides immediate delivery of feedback and rewards (Shores & Chester, 2009).

Among the general population of students, CAI was found to be particularly effective for improving reading skills in younger students, lower achievers, and children with specific learning disabilities, producing better results than with conventional instruction alone (Storey et al., 2017). CAI can be beneficial as a brief, targeted intervention for students identified as "at-risk" for falling behind (Hall et al., 2000), suggesting it could be one potential solution needed in the current climate.

1.2 | Headsprout early reading program

Headsprout Early Reading (HER; 2018) is an example of CAI for early literacy skills, developed by behavior analysts to teach skills in the five key areas of reading; phonemic awareness, phonics, fluency, vocabulary, and comprehension (National Reading Panel, 2000). Children master essential reading skills while interacting with cartoon characters in child-friendly environs, such as Space, Dinosaur World, Underwater, and the Jungle.

The program aims to bring beginner readers up to a proficient level upon completion of the 100 20-min episodes (Layng et al., 2004) and utilizes four key learning strategies: reduced errors, mastery criterion, guided practice, and cumulative review (Storey et al., 2017). Headsprout uses errorless discrimination and stimulus fading to ensure correct responding from the outset, reducing the frustration of trial and error for learners. The program ensures that specific learning goals are met before the child moves onto the next instructional segment. Guided practice allows learners to rehearse and consolidate newly acquired skills while being guided or "scaffolded" by the program. Supports are gradually withdrawn as the learner builds fluency and accuracy which in turn improves the retention of new skills and encourages automaticity of reading. Headsprout revisits, reuses, and extends on previously taught skills to further improve the retention of new reading skills (Layng et al., 2004). There is a rich schedule of reinforcement built into each episode with high levels of verbal praise delivered by the cartoon characters and a visual target that the character moves closer with each correct response. In addition, there is an inbuilt token reward system for completion of episodes.

Headsprout resembles behavior analytic instructional programs such as the Personalized System of Instruction (Kim & Axelrod, 2005) and Direct Instruction (Watkins, 1988) and has a strong theoretical basis in these strategies. For example, match to sample, fluency building, trials to criterion, and praise or rewards delivered for correct responding.

In addition to Headsprout, incorporating many evidence-based teaching strategies, the program itself has also been the focus of recent research. Rigney et al. (2020) conducted a systematic review of the existing literature base for Headsprout. Out of 44 studies returned in database searches, six met the following inclusion criteria: conducted in a school setting, used an experimental design that allowed for calculation of effect sizes, and published in peer-reviewed journals. Of those six papers, only two met the What Works Clearinghouse (WWC) standards. The systematic review found that there was overall support for Headsprout as an intervention. However, the limited amount of existing research and overall poor methodology of those studies did not allow for any strong conclusions to be drawn.

1.2.1 | Headsprout for "at-risk" children

Rigney et al. (2020) identified several studies supporting the use of Headsprout for children at-risk of falling behind in literacy skills (e.g., Cullen et al., 2014; Huffstetter et al., 2010; Kreskey & Truscott, 2016). Storey et al. (2017) investigated the efficacy of Headsprout as a supplementary tool to improve literacy skills of children who spent time in-care and were at risk of reading failure. Posttest scores showed greater gains in word recognition age and oral reading fluency for the Headsprout learners when compared with the waitlist-control group. These outcomes support the wider use of Headsprout as a supplementary tool to help children at-risk of falling behind to improve literacy skills.

1.2.2 | Headsprout as a parent-mediated intervention

Grindle et al. (2019) evaluated the use of Headsprout as a parent-mediated intervention for children with Down syndrome. All five children demonstrated meaningful improvements in reading after completing an average of 41 episodes over a 6-month period, with word reading age increasing on average by 13 months (range 6–20 months) and improved phonemic segmentation skills. Parents were given access to a private Facebook group where they could ask questions about the intervention or seek help for technical issues from the researcher. Social validity measures found that parents were satisfied with the intervention, demonstrating Headsprout's suitability as a parent-mediated intervention, due to its ease of implementation and the minimal direction required from parents. However, some participants demonstrated much larger gains than others, which may be explained by their level of engagement. Further research would help to identify variables that may significantly moderate the efficacy of Headsprout as a parent-mediated intervention and determine the optimum conditions for implementation.

1.2.3 | Headsprout with implementation support

Watkins et al.'s (2016) study provided important insight into how varying approaches to the implementation of Headsprout may influence the efficacy of the program. Experimenters evaluated the use of Headsprout to improve early reading skills (i.e., catch-up) for primary school pupils, including those identified as "at-risk" and/or scoring well below average on norm-referenced assessments. The study also compared outcomes for pupils in School A, where Headsprout was implemented *without* implementation support, and School B, where Headsprout was implemented *with* ongoing support from the experimenter. A comparison of scores from pre- and posttest assessments support previously reported findings that Headsprout is an effective supplementary reading program for "at risk" readers. Students in School A completed an average of 48 episodes during the intervention period compared to 22 episodes for School B. However, there was a greater improvement in reading scores for children in school B, where implementation support was provided to teachers in the form of weekly school visits to review pupil data and offer advice. Email and phone support were also offered for technical issues. Additional analysis indicated differences in the quality and consistency of Headsprout implementation between the two schools. In contrast to School A, School B completed regular benchmark assessments with pupils and completed a checklist after each episode. This information was used to identify students who needed to repeat episodes or avail of fluency-building practice. School B also provided progress maps to mark off completed episodes and rewarded pupils with stickers and certificates, while School A chose not to avail of these resources. These findings suggest that fidelity of implementation may have a greater impact on pupils' outcomes than intensity and that schools can deliver the program more effectively with additional support. To date, there are no studies evaluating the impact of implementation support on home-based programs. Therefore, it is possible that fidelity of implementation and level of support provided could have similar effects on outcomes when using Headsprout as a parent-mediated intervention.

1.3 | Purpose of the current research

Taken together, the impact of the pandemic on children's reading may be profound and there is an urgent need to identify effective supplementary reading interventions. CAI is one possible intervention that can be implemented at home with Headsprout already having some evidence to support its use. However, the use of HER as a parent-mediated intervention and the extent to which parents can implement this program without support remains unknown. Therefore, the purpose of the present study was threefold: (a) to investigate if providing support to parents using the Headsprout program leads to increased fidelity of implementation and better reading outcomes, (b) to examine if children's reading skills improved as a result of receiving Headsprout instruction, and (c) to evaluate the impact of moderators on the effectiveness of Headsprout.

2 | METHOD

2.1 | Participants

Thirty-six primary school children (20 females and 16 males) participated in the study. All participants (hereafter referred to interchangeably as children) attended mainstream primary schools across the west of Ireland and were aged between five and 9 years. All schools were using well-established phonic programs as their main method of teaching reading skills, with none availing online literacy programs at the time of the study. All children returned to classroom learning during week 3 of the intervention following extended school closures. Week one and two coincided with Easter holidays. All children met the inclusion criteria in relation to skills required to access Headsprout: (a) follow simple instructions, (b) attend to a computer for up to 20 min, (c) imitate spoken words and sounds, and (d) respond to feedback (praise or correction).

2.2 | Setting

Teaching sessions were conducted in the child's home, in a suitable location chosen by the parent, and where the child could access Headsprout episodes without distractions. The children completed episodes outside of school hours, with a parent nearby to assist when required.

2.3 | Materials and apparatus

2.3.1 | Headsprout early reading

The primary instructional components of HER were (a) 100 online episodes, each approximately 20 min in length; (b) the Headsprout stories, accessed upon completion of each episode; and (c) the Headsprout Benchmark stories, automatically administered after every 10 episodes. HER also had a built-in reward system, which awarded badges for reaching milestones and stars that could be exchanged for items to personalize avatars and Raz Rockets. Parents had the option to download a progress map for their child to mark off each completed episode. Performance data per episode was automatically recorded by Headsprout for each child and stored in the Teacher Portal. Data included the number of episodes completed, episode's accuracy (displayed as a percentage score indicating mastery), and duration of each episode. Participants used personal laptops and tablet devices to meet with the research team via Zoom or Microsoft Teams for remote assessments and to also complete the Headsprout episodes.

All assessments were conducted using (a) a standard protocol developed by the lead author, (b) adapted student materials suitable for remote testing, downloaded from the DIBELS website and presented in PowerPoint, and (c) Headsprout Benchmark Stories also presented in PowerPoint. An instructional guide was compiled by the experimenter in PDF format, to provide parents with an overview of HER and step-by step instructions for getting started with the program. The guide also described the features of Headsprout, how to complete the placement test, and some "helpful tips and tricks" for parents to get the most out of the program.

2.4 | Design

A stratified randomized controlled trial (RCT) design was used to ensure balance of reading abilities across the three groups and control for any possible influence of covariates that could jeopardize the conclusions of the research. Participants were ranked based on the sum of their pretest scores and split into three levels: (1) 12 highest scores, (2) 12 lowest scores, and (3) 12 mid-range scores. Participants were then randomly assigned from within each level to one of the three intervention groups: (1) Headsprout with implementation support (HWS), (2) Headsprout without implementation support (HWOS), and (3) waitlist-control, resulting in 12 participants in each intervention group.

2.5 | Dependent variables

2.5.1 | Episode completion

Parents were asked to complete three or more episodes each week, in line with Headsprout recommendations for optimum results (Headsprout, n.d.). The number of episodes completed was recorded as an outcome measure for fidelity of implementation.

2.5.2 | Dynamic Indicators of Basic Early Literacy Skills

Children's early reading skills were assessed, pre- and posttest, using the 8th Edition of Dynamic Indicators of Basic Early Literacy Skills (DIBELS; University of Oregon, 2018). This was chosen for its focus on assessing and monitoring

the acquisition of beginner reading skills and its use in published outcome studies on reading skills (University of Oregon, Center on Teaching and Learning, 2018). All children were assessed using the First Grade Scoring Booklet Benchmark Assessment for the first two subtests; *Letter Naming Fluency (LNF)*, which measures the ability to label letter names and *Phonemic Segmentation Fluency (PSF)*, which measures the ability to segment three and four phoneme words into individual phonemes. The other three subtests were administered using either first or second grade materials depending on the class level of the child. *Nonsense Word Fluency (NWF)* measures the ability to apply alphabetic principle skills to read/decode words. There are two scores produced for this subtest; NWFcorrect letter sounds and NWF—words read correct. These scores were added together to provide a total score for NWF. *Word Reading Fluency (WRF)* measures accuracy and fluency of oral reading skills, and *Oral Reading Fluency (ORF)* measures accuracy and fluency of oral reading and comprehension skills. The child's total score for each subtest was the number of correct responses provided in 1 min. Change scores (posttest score minus pretest score) were used as the dependent variable for analyzing the impact of moderators on three reading-dependent outcome measures: NWF, ORF, and STORY.

2.5.3 | Headsprout Story (STORY)

In addition to the DIBELS assessment, children were also assessed on their word reading fluency and accuracy, using the Headsprout Benchmark Stories (referred to as STORY hereafter). The rate of correct words per minute was the outcome measure for this variable calculated as (Total number of words read − Number of errors)/Time taken to read story (seconds) × 60.

2.6 | Moderators

Data collected from the individual participant's reports generated by the Headsprout program were used to create moderator variables for further analysis. The *performance* moderator variable was the mean average of all performance scores per episode calculated for each participant. The sum total of all *duration per episode* times was used as the *intensity* moderator variable. The *last episode completed* moderator variable measured each participant's final placement within the program. *Participant age* was also included as a moderator for analysis.

2.7 | Procedure

2.7.1 | Pre-intervention

Parents were informed of the study by email, which was distributed through school principals. The email contained a link to an online registration form, where parents consented to their child taking part in the study and provided basic contact details. The experimenter then contacted parents to schedule the pretest assessment, which was conducted remotely via Microsoft Teams or Zoom.

Children were assigned to intervention groups and parents of children in the two groups receiving Headsprout instructions were given access to the Headsprout instructional guide that they could access in their own time. The experimenter was available to assist with any issues encountered during set-up and all parents were offered support for technical issues throughout the intervention period, regardless of the intervention group to which they were assigned.

2.7.2 | Intervention

The HER placement test was completed by each child prior to starting episodes. The test identified the child's current reading ability and assigned them to a developmentally appropriate starting episode within the program. Parents

were then required to implement the program with their child over a 10-week intervention period from March 2021 to June 2021 in accordance with the Headsprout implementation guidelines as follows.

The recommended practice was for children to complete three episodes per week and for parents to sit beside their child to facilitate logging in to the program and ensuring headphones were connected. Parents could help to keep their child engaged by offering praise and encouragement or prompt them to speak out loud during certain activities, but they were advised not to help in any other way as that might interfere with HER's inbuilt correction and feedback procedures, resulting in inaccurate data relating to the child's ability and progress. Parents also had the choice to provide their child with more personalized rewards or reinforcement for completing episodes if they felt it would help to keep the child motivated. Throughout the 10-week intervention period, children in both intervention groups also continued with their usual schoolwork and accessed the same literacy curriculum as the waitlist-control group.

Headsprout with support (HWS)

For children assigned to the "Headsprout with implementation support" condition, the experimenter monitored each child's performance and provided parents with on-going implementation support throughout the 10-week intervention period. This support took the form of weekly or fortnightly check-ins via email, to offer advice and assistance with how to implement HER with their child. The experimenter also provided parents with updates regarding their child's episode completion and how it compared to the recommended three episodes per week (i.e., ahead of target, on track, and behind target). Headsprout data were monitored remotely by the experimenter to identify children who scored below 80% on three consecutive episodes. In this instance, targeted practice fluency building exercises using flashcards were available to parents when required. A modified version of Watkins et al.'s (2016) implementation checklist was used for parents in the HWS group to monitor the following components: episode completion, consistent delivery of rewards and praise, use of the progress map, level of parental support, performance score, and troubleshooting measures required (see Supporting Information S1).

Headsprout without support (HWOS)

Parents in this group did not receive ongoing support throughout the intervention period. After initial set-up, the experimenter did not contact parents in this group to discuss their progress or monitor the child's data for performance scores but did provide assistance for technical issues.

Waitlist-control

A waitlist-control group was established to allow for the comparison of performance with pupils using HER. The group consisted of all non-HER pupils from the same classes as the intervention groups. Pupils in this group followed the same taught curriculum as the HWS and HWOS groups, delivered by the same class teachers, but had no access to Headsprout during the 10-week intervention period.

2.7.3 | Post-intervention

At the end of the 10-week intervention period, a further 2-week block was allocated to complete the posttest assessments for all children. Following the assessments, parents in the waitlist-control group were provided with the set-up guide and login details to Headsprout for 10 weeks. Parents in the HWS and HWOS intervention groups were provided with a debrief form and a link to an online feedback questionnaire to measure social validity of the Headsprout program. The Social Validity Questionnaire consisted of two sections: part A was completed by parents and part B by the child (see Supporting Information S2).

2.8 | Assessment agents and training

Assessments were conducted by the experimenter (lead author) and four Master level students, completing university postgraduate training in Applied Behavior Analysis. Group training sessions in the DIBELS and Headsprout Story assessments were provided by the experimenter to the four other assessors prior to conducting pre- and posttest assessments.

A behavior skills training package was used, with the experimenter providing written and verbal instruction on the procedure for conducting assessments. The experimenter provided scripts for assessors to use for each sub-test to ensure consistency between assessors. The experimenter also provided a training video of an assessment to model the correct procedure. Assessors then meet up online in pairs to practice running assessments, taking it in turns to role play as the assessor and the child. Recordings of the practice sessions were sent to the experimenter for review and feedback was provided. The experimenter used a modified version of the DIBELS fidelity checklist (University of Oregon, 2020) to accommodate procedural changes for remote testing.

2.9 | Interobserver agreement

To calculate interobserver agreement (IOA) on assessment scores, each assessment was recorded through the Zoom or MS Teams function. In total, 22% of the recordings ($n = 8$) were viewed and scored by a second observer. IOA was calculated by dividing the number of observer agreements by the number of judgments. IOA was above 95% for all pre- and posttest assessments of all participants.

2.10 | Data analysis

Prior to running statistical analysis, preliminary screening was conducted to ensure all assumptions were met. An independent samples *t*-test was used to evaluate the effects of implementation support between groups, using the number of episodes completed as the dependent variable and intervention groups (HWS and HWOS) as the independent variable.

A multivariate analysis of covariance (MANCOVA) was used to compare post-intervention scores for the DIBELS assessment between the three experimental groups. An analysis of covariance (ANCOVA) was also used to compare posttest scores between groups for the STORY measure. The covariate adjustment for pretest scores accounted for the variation in the children's pre-intervention reading skill levels and allowed for an analysis of posttest differences truly resulting from the intervention.

Hierarchical Multiple Regression (HMR) analyses were conducted to investigate the impact of moderators on change scores for the reading-dependent measures of NWF, ORF, and Headsprout Benchmark Story (STORY). Intercorrelations between the regression variables were identified using Pearson's product moment to inform the structure of the multiple regression models. The three most highly correlated variables for each outcome were then analyzed through the regression model.

3 | RESULTS

Forty parents completed the online registration form; however, four withdrew prior to completing the pretest assessment. The final total of 36 participants all completed pre- and posttest assessments in March and May–June 2021, respectively. Participants' composite scores (i.e., sum of scores from each assessment sub-test) are presented in Table 1. The 12 participants in the HWS group had a mean age of 8.25 years ($SD = 0.29$) with seven females and five

TABLE 1 Participant age, intervention group and composite scores from pre- and post-test assessments.

Participant	Age	Group	Episodes completed	Pre-test score	Post-test score	Pre-post test change	Change score as a %
2	5y 10m	HWS	30	67	132	65	97
4	7y 5m	HWS	48	94	333	239	254
5	7y 7m	HWS	31	314	527	213	68
12	7y 11m	HWS	22	362	423	62	17
14	8y 1m	HWS	34	486	596	111	23
20	8y 4m	HWS	30	483	498	14	3
25	8y 6m	HWS	33	438	479	41	9
26	8y 7m	HWS	9	270	289	19	7
31	8y 10m	HWS	30	331	472	141	43
34	9y 2m	HWS	2	136	171	35	26
35	9y 5m	HWS	34	448	554	106	24
36	9y 5m	HWS	5	25	44	19	76
Mean score (*SD*) for HWS				288 (48.64)	377 (52.29)	89 (21.91)	54 (20.16)
1	5y 9m	HWOS	19	292	417	125	43
6	7y 7m	HWOS	5	151	267	115	76
8	7y 9m	HWOS	7	166	252	86	52
11	7y 11m	HWOS	31	216	230	13	6
13	8y 1m	HWOS	6	199	265	66	33
19	8y 4m	HWOS	21	316	377	60	19
21	8y 5m	HWOS	18	446	570	124	28
22	8y 5m	HWOS	8	176	286	110	63
24	8y 6m	HWOS	21	213	271	58	27
27	8y 7m	HWOS	15	708	686	−23	−3
32	8y 11m	HWOS	8	567	628	61	11
33	9y 0m	HWOS	18	528	581	53	10
Mean score (*SD*) for HWOS				331 (53.92)	402 (48.62)	72 (13.16)	31 (7.32)
3	6y 7m	CONTROL	-	182	225	43	24
7	7y 9m	CONTROL	-	678	661	−17	−3
9	7y 10m	CONTROL	-	254	204	−50	−20
10	7y 10m	CONTROL	-	245	353	107	44
15	8y 4m	CONTROL	-	348	344	−3	−1
16	8y 4m	CONTROL	-	547	691	144	26
17	8y 4m	CONTROL	-	654	702	48	7
18	8y 4m	CONTROL	-	383	484	101	26
23	8y 5m	CONTROL	-	340	410	70	21
28	8y 7m	CONTROL	-	288	417	129	45
29	8y 8m	CONTROL	-	232	327	95	41
30	8y 8m	CONTROL	-	515	618	103	20
Mean score (*SD*) for CONTROL				390 (48.81)	453 (51.12)	63 (17.64)	19 (5.76)

Abbreviations: HWOS, Headsprout without implementation support; HWS, Headsprout with implementation support.

males. The 12 participants in the HWOS group had a mean age of 8.10 years (*SD* = 0.25) with four females and eight males. The 12 participants in the waitlist-control group had a mean age of 8.14 years (*SD* = 0.17) with nine females and three males.

3.1 | Between group comparisons

3.1.1 | Evaluating the impact of implementation support on episode completion

An independent-samples *t*-test was conducted to evaluate if there was a significant difference in the implementation of Headsprout between the two intervention groups: HWS and HWOS. The independent variable was implementation support, and the dependent variable was the total number of episodes completed over the 10-week period. The results showed that there was a significant difference in the number of episodes completed between the two groups (t (22) = 2.39, p = 0.026, d = 0.975). Children in the HWS group completed more episodes (M = 25.67, *SD = 13.67*) than children in the HWOS group (M = 14.75, *SD = 8.00*).

3.1.2 | Dynamic Indicators of Basic Early Literacy Skills

Formative evaluations of Headsprout and reading outcomes were based on the completion of at least seven episodes of the program. On this basis, two children in the HWS group and two children in the HWOS group were excluded from this statistical analysis. The final sample for analysis numbered 32 participants: 10 participants in the HWS group (Female = 6, Male = 4), 10 participants in the HWOS group (Female = 3, Male = 7), and 12 participants in the waitlist-control group (Female = 9, Male = 3). A one-way MANCOVA was conducted to examine if children's reading skills improved as a result of receiving Headsprout, by determining the effects of *intervention group* on post-intervention scores for the DIBELS assessment. Pretest scores were used as a covariate to control the current ability level. There was no statistically significant difference between the intervention groups on the posttest scores after controlling for pretest scores, F(10, 40) = 1.040, p = 0.430, Wilks' Λ = 0.630, and partial $\eta 2$ = 0.206. However, the adjusted group means were greater for the HWS group compared to the HWOS and waitlist-control groups for three of the five DIBELS sub-tests; NWF, WRF, and ORF (see Figure 1 and Table 2).

3.1.3 | Word reading fluency for Headsprout Benchmark Story (STORY)

A one-way ANCOVA was conducted on the same sample (N = 32) to determine the effect of Headsprout on post-intervention word reading fluency scores for the STORY measure after controlling for pretest performance. The adjusted means for the posttest scores were greater for the HWS group (M = 91.68, SE = 3.68) compared to the HWOS Group (M = 84.83, SE = 3.69) and the waitlist-control group (M = 83.53, SE = 3.36), respectively (see Figure 2 and Table 2). After adjustment for pre-test scores, there was no statistically significant difference in post-test scores between the interventions, F(2, 28) = 1.487, p = 0.243, partial $\eta 2$ = 0.096.

3.2 | Evaluating the impact of moderators on reading-dependent outcome measures

HMR analyses were conducted for each of the outcome measures (NWF, ORF, and STORY). A total sample size of 24 participants from the HWS (n = 12) and HWOS (n = 12) groups were included for analysis and the relevant assumptions were satisfied. See Table 3 for results.

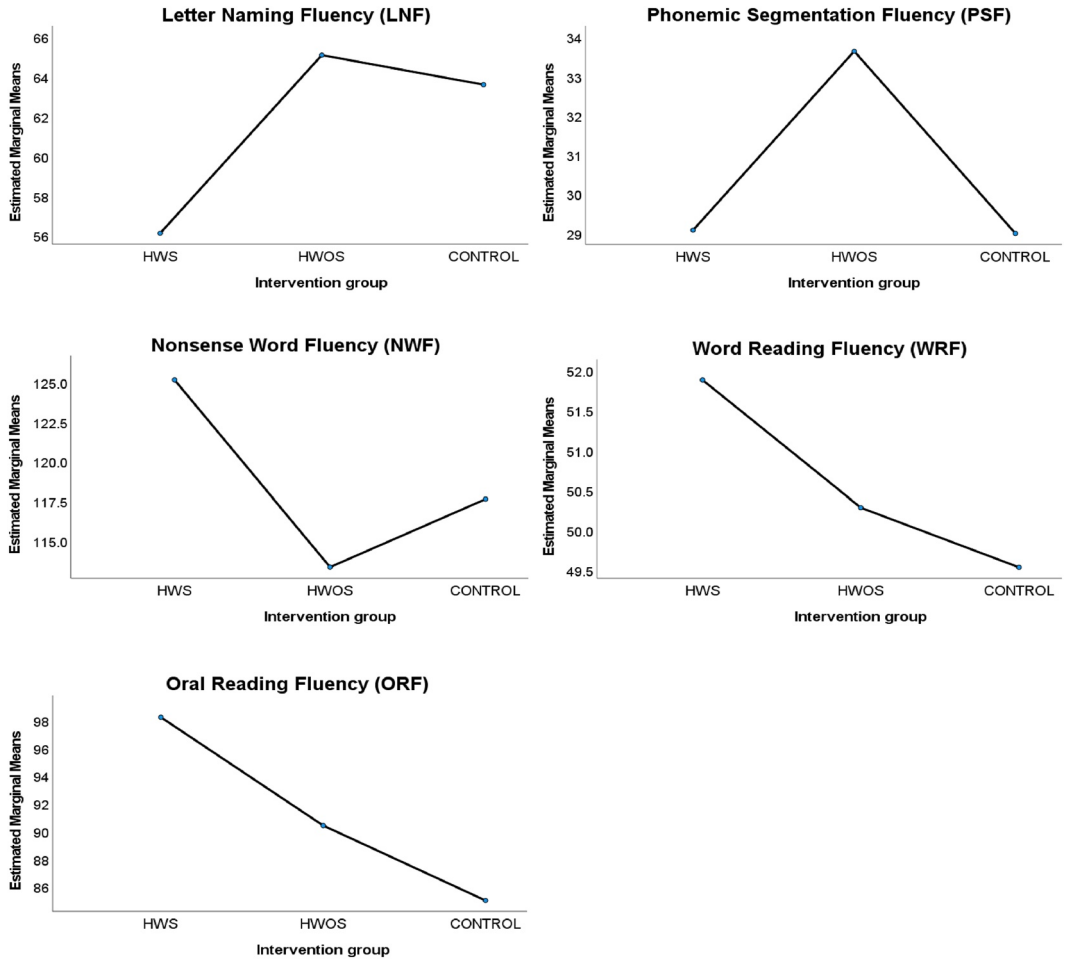

FIGURE 1 Profile plots of DIBELS post-test adjusted mean scores for each of the intervention groups. Covariates appearing in the model are evaluated at the following values: Pre LNF = 48.09, Pre PSF = 22.13, Pre NWF = 103.03, Pre WRF = 43.84, Pre ORF = 78.00. HWS, Headsprout with implementation support; HWOS, Headsprout without implementation support; LNF, Letter Naming Fluency; NWF, Nonsense Word Fluency; ORF, Oral Reading Fluency; PSF, Phonemic Segmentation Fluency; WRF, Word Reading Fluency.

3.2.1 | Moderators for Nonsense Word Fluency outcomes

The full model of last episode completed, intensity, and performance to predict NWF outcomes was not statistically significant, $R^2 = 0.305$, $F(3, 20) = 2.924$, $p = 0.059$, *adjusted* $R^2 = 0.201$. The addition of participant age and performance scores in the first step (Model 1) led to a statistically significant increase in R^2 change of 0.263, $F(2, 21) = 3.746$, $p < 0.05$.

3.2.2 | Moderators for Oral Reading Fluency outcomes

The full model of *intensity*, *performance*, and *last episode completed* as predictor variables of ORF outcomes was statistically significant, $R^2 = 0.362$, $F(3, 20) = 3.784$, $p < 0.05$; *adjusted* $R^2 = 0.266$. The addition of *last episode completed* in step two as a moderator of ORF outcomes led to a statistically significant increase in R^2 of 0.173, $F(1, 20) = 5.42$, $p < 0.05$.

TABLE 2 Group mean and adjusted mean scores for pre- and post-test reading assessment.

		Pre-test (standard means)		Post-test (standard means)		Post-test (adjusted means)	
Dependent variable	**Group**	***M***	***SD***	***M***	***SD***	***Madj***	***SE***
Letter Naming Fluency (LNF)	HWS	41.30	21.73	52.50	23.27	58.12	4.30
	HWOS	51.40	23.22	65.90	19.59	57.34	4.19
	CONTROL	51.00	23.64	65.92	25.45	57.92	4.13
Phonemic Segmentation Fluency (PSF)	HWS	20.90	10.61	28.90	8.88	29.11	2.30
	HWOS	21.10	11.35	33.30	9.12	31.51	2.24
	CONTROL	24.00	12.93	29.42	13.71	31.59	2.21
Nonsense Word Fluency (NWF)	HWS	85.30	47.98	113.60	47.16	112.40	8.00
	HWOS	107.80	65.69	113.30	55.78	103.65	7.80
	CONTROL	113.83	65.41	127.25	56.52	103.52	7.69
Word Reading Fluency (WRF)	HWS	41.20	24.06	49.90	26.09	48.47	4.69
	HWOS	42.20	21.85	47.80	23.89	44.48	4.57
	CONTROL	47.42	25.81	53.25	28.38	44.89	4.51
Oral Reading Fluency (ORF)	HWS	72.60	40.04	92.90	45.12	89.85	8.10
	HWOS	75.70	50.34	87.40	51.53	78.82	7.90
	CONTROL	84.42	40.82	91.92	45.98	78.01	7.79
Headsprout Benchmark Story (STORY)	HWS	68.00	21.83	92.50	15.90	91.68	3.68
	HWOS	63.43	44.41	81.95	35.65	84.83	3.69
	CONTROL	69.09	29.47	85.24	31.36	83.53	3.36

Abbreviations: HWOS, Headsprout without implementation support; HWS, Headsprout with implementation support.

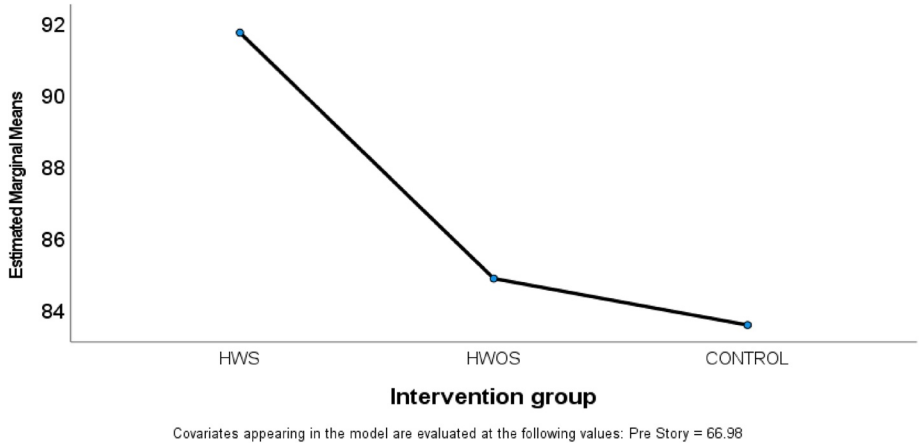

FIGURE 2 Profile plot of the post-test estimated marginal mean scores for each of the intervention groups in the Headsprout Story Assessment. HWS, Headsprout with implementation support; HWOS, Headsprout without implementation support.

3.2.3 | Moderators for Headsprout Benchmark Story (STORY) outcomes

The full model of *age*, *performance*, and *intensity* to predict outcomes for the STORY measure was statistically significant, F (3, 20) = 6.567, p < 0.01 and accounted for 49.6% of the variance (*adjusted* R^2 = 0.421). The addition of

TABLE 3 Summary of hierarchical multiple regression analyses for assessing the impact of moderators on outcome measures for reading-dependent change scores.

Variable	*β*	R^2	R^2 change	*F* change
HMR 1—Nonsense Word Fluency (NWF) as outcome measure				
Step 1		0.26	0.26	3.75*
Participant age	−0.26			
Performance	−0.40*			
Step 2		0.31	0.04	1.21
Participant age	−0.18			
Performance	−0.33			
Intensity	0.24			
HMR 2—Oral Reading Fluency (ORF) as outcome measure				
Step 1		0.19	0.19	2.45
Performance	−0.12			
Intensity	0.38			
Step 2		0.36	0.17	5.42*
Performance	−0.26			
Intensity	0.13			
Last episode completed	0.48*			
HMR 3—Headsprout Benchmark Story (STORY) as outcome measure				
Step 1		0.21	0.21	5.87*
Participant age	−0.46*			
Step 2		0.50	0.29	5.67*
Participant age	−0.25			
Performance	−0.31			
Intensity	0.39			

Note: $N = 24$.

*$p < 0.05$.

participant age as the first moderator in step one contributed significantly to the regression model, $F(1, 22) = 5.872$, $p < 0.05$ and accounted for 21.1% of the variance in outcome measures. Introducing *performance* and *intensity* scores as moderators in step two explained an additional 28.6% of the variation and led to a significant change in R^2, $F(2, 20) = 5.668$, $p < 0.05$.

3.3 | Social validity

Twenty-three parents completed the Social Validity Questionnaire (12 from HWS and 11 from HWOS). When asked if they thought their child enjoyed Headsprout: 26% responded "Yes"; 47% responded "most of the time"; 21% responded "some of the time"; and 4% responded "no" ($n = 6$, 11, 5, and 1, respectively). For the six parents who responded "no" or "some of the time," they were asked what the main reason was for their child not enjoying Headsprout. Five parents felt the episodes were too repetitive, and one parent said their child found the episodes difficult. Parents were asked if Headsprout improved their child's reading skills. Six parents (26%) said "yes, a lot." Eight parents (35%) said "yes, a little," and nine parents (39%) reported "no change." When asked if they would use Headsprout in the future; 30% responded "maybe," 17% responded "no," and 52% responded "yes" ($n = 7$, 4, and 12, respectively).

For the child feedback, 30% of children "liked" or "loved" Headsprout, 43% felt it was "ok," and 26% "did not like some of it." No children responded that they did not like Headsprout at all. When asked if they felt Headsprout helped with their reading; 70% felt it helped a little, 17% felt it helped a lot, and 13% felt that it did not help (n = 16, 4, and 3, respectively). Seven children reported that they would use Headsprout again, three reported that they would not, and the remaining 13 children might use it again. A common complaint among children, when asked what they disliked about Headsprout, was the repetitiveness of the episodes (n = 14).

4 | DISCUSSION

The current research investigated the efficacy of Headsprout as a parent-mediated reading instruction to supplement the general education literacy curriculum. The primary research question sought to establish if the provision of implementation support for parents led to increased fidelity of implementation of the Headsprout program and better outcomes for the child. The current research also examined if children's reading skills improved as a result of using Headsprout and if there were any moderators that had a significant impact on the effectiveness of Headsprout as an intervention.

A stratified RCT was used to evaluate between group differences and the results tentatively suggest that children in the HWS group experienced greater gains in reading skills and achieved a higher level of fidelity in the implementation of Headsprout. A further analysis was conducted to examine the effects of *age*, *performance*, *intensity*, and *last episode completed* as moderators on the efficacy of Headsprout, which demonstrated significant interactions between the moderators and reading-dependent outcomes.

4.1 | Impact of implementation support

The current study evaluated the impact of implementation support on the fidelity and quality of Headsprout instruction when mediated by parents. Two treatment groups were established: *with support* and *without support*. The total number of episodes completed was used as a measure of implementation fidelity for statistical analysis. It was recommended to parents that their child complete an average of three episodes per week for optimum results. This would equal a total of 30 episodes by the end of the 10-week trial. Children in the HWS group performed significantly better in meeting the target number of episodes with an effect size of 98%. They completed an average of 26 episodes, with 67% (n = 8) of the group completing 30 or more episodes. Children in the HWOS completed an average of 15 episodes, with only one child (8%) in the group completing 30 or more episodes. These findings are consistent with Watkins et al.'s (2016) study, who found that providing support to teachers led to improved fidelity of implementation. Results of this study show that providing support to parents led to 59% more children reaching the recommended three lessons per week compared to the *without support* group.

Further analysis revealed that the HWS goup produced better outcomes for students, with an overall increase of 54% between pre- and posttest scores (see Table 1). In comparison, the HWOS group's pre- to posttest scores increased by 31% and the waitlist-control group by 19%. These results demonstrate the benefits of providing support to parents when implementing Headsprout and consideration of such findings may be useful when developing best practice guidelines around the use of parent-mediated interventions to supplement school-based literacy programs.

4.2 | Efficacy of headsprout to improve reading skills

The between groups analysis of posttest reading assessment scores revealed that children who received Headsprout instructions made greater gains across all reading measures compared to the waitlist-control group. The HWS group

outperformed the other groups in four of the six outcome measures (NWF, WRF, ORF, and STORY). The HWOS group outperformed the other groups for the remaining two measures (LNF and PSF) as can be seen in Figure 2. Although findings in the current research are consistent with previous studies that support the use of Headsprout to improve reading skills (Huffstetter et al., 2010; Storey et al., 2017, 2020; Tyler et al., 2015; Watkins et al., 2016), the difference in gains across groups was not large enough to reach significance.

4.3 | Impact of moderators on reading-dependent outcome measures

There was a wide range of ages and abilities spread across the groups, which captures the typical demographics of an Irish primary classroom, where it is not unusual to have one teacher instructing multiple grades in one classroom. The results above suggest that most children can benefit from Headsprout instruction, but further analysis of factors was required to develop a more meaningful understanding of individual differences that could impact on the efficacy of Headsprout.

The regression analyses demonstrated that age was a significant predictor of outcome measures, with younger children (i.e., beginner readers) showing most improvement. Intensity of the intervention along with performance levels and progress through the program were also significant predictors of reading-dependent outcome measures. These findings further support the importance of fidelity of implementation to produce best outcomes for the child. More intensive instruction produces larger gains as does the child's final episode placement. The further they progress in the program, the more gains they will achieve.

These findings suggest that there may be some individual differences to consider when using Headsprout in applied settings. Improvements in reading outcomes as a result of the HER program may not be as noticeable for older children aged eight onward. This is particularly true for advanced readers who have mastered the decoding stage of reading and are in the early stage of becoming a fluent, comprehending reader (Wolf & Stoodley, 2007). The Grade One and Two DIBELS subscales used as assessment tools may be subject to a ceiling effect for these individuals and fail to detect more advanced skill acquisition not targeted in those subscales.

4.4 | Social validity

Although parents found the Headsprout program very accessible and easy to set up, 38% of parents reported difficulty completing three episodes each week, resulting in them doing less than the recommended amount. Grindle et al. (2019) received similar feedback from parents when investigating the efficacy of Headsprout as a parent-mediated intervention. The biggest barrier was time constraints in both studies, with children being too tired or busy after school or the parents themselves not having time to sit with their child. Children in the current study were completing Headsprout in addition to their usual homework, which parents found challenging. However, teachers using Headsprout as a class-wide tool could assign episodes as homework, in place of typical homework, so as to eliminate the need to find extra time to run the program.

Poor Internet connectivity was an issue for some parents, resulting in fewer episodes being completed. This is an important consideration prior to embarking on the use of Headsprout or indeed any digital instruction as a parent-mediated resource. A basic requirement will be for all children to have access to computer devices and adequate Internet connection. This may not always be feasible, particularly in households where there are a number of siblings requiring access to CAI at the same time in order to complete their homework.

As with previous studies, overall acceptability for Headsprout among parents was high (Grindle et al., 2019) with the majority of parents reporting that their child's reading has improved as a result of using Headsprout. Most children responded that they liked, loved, or thought Headsprout was “ok,” suggesting high rates of acceptability, with almost 87% responding that they felt Headsprout helped with their reading.

4.5 | Limitations and future directions

Although the findings present tentative support for the use of Headsprout as a home-based parent-mediated intervention, there are several limitations to the study. A priori power analysis was conducted using G*Power, which recommended a minimum sample size of 42 participants (14 per group) to produce significant results ($p < 0.05$) for the main interaction between groups. The number of participants recruited ($N = 36$) was below this suggested sample size, which may explain why some outcome measures did not achieve significance, particularly in the between groups analysis of posttest reading assessment scores, where four participants were excluded from analysis, reducing the sample size further ($N = 32$). A larger sample size with a wider range of demographics would be beneficial in future research.

The current research used an implementation checklist with parents in the HWS group, to monitor compliance with implementation recommendations and troubleshoot any issues. However, as no such data were collected from the HWOS group, it was not possible to compare the degree to which parents followed implementation guidelines between the *with support* and *without support* groups. Future studies could address this gap in the research.

A further limitation of the current research is the time allocated for intervention. It could be argued that 10 weeks is not sufficient to allow for significant improvements in reading abilities, to the extent that they can be reliably detected using standardized testing. Future studies could implement more stringent screening processes and target specific cohorts of primary school children to a greater extent than the current research, particularly younger children. In addition, researchers could consider incorporating norm-referenced assessment measures, such as the Weschler Individual Achievement Test (WIAT-III; Weschler, 2009). As the current research was conducted in the midst of a pandemic and national lockdowns, all assessments were conducted remotely. In this context, a slightly older age range of children was recruited due to their ability to participate reliably in remote assessments. There was a risk that younger children would have difficulty completing the assessments online. Given the findings from this study in relation to outcomes declining with age, it is possible that more marked differences would arise for a younger population of children receiving Headsprout instructions under similar conditions.

5 | CONCLUSION

The current study demonstrates that parents can effectively implement the Headsprout program in-home, when provided with ongoing support. A comparison of outcomes between intervention groups demonstrated significantly higher levels of engagement for the *with support* condition compared to the *without support*. These findings could be explored further with a more in-depth analysis of the fidelity of implementation by parents, depending on whether they receive support or not. Children receiving Headsprout instruction demonstrated greater improvements in posttest reading-dependent outcomes compared to the waitlist-control group, although not to a significant level. Future studies should expand on these findings by conducting similar research on a larger population with a greater focus on younger children. Findings from the current research support the use of Headsprout as a class-wide intervention for children in need of "catch-up" instruction. Given the amount of instructional time that children have lost as a result of extended school absences during the pandemic, these findings are particularly pertinent. Further analysis of the minimum intensity required to produce results would also be beneficial as reducing the recommended number of weekly episodes or shortening the amount of time required to complete each episode would reduce demands on parents and children as well as increase the social validity of Headsprout as a parent-mediated intervention.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Consent was obtained from all participants.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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